28-29 September 2023,
Kragujevac, Serbia

www.iccbikg2023.kg.ac.rs

2nd International Conference on Chemo and Bioinformatics
ICCBIKG_2023

BOOK OF PROCEEDINGS

2nd International Conference on Chemo and BioInformatics

ICCBIKG 2023

BOOK OF PROCEEDINGS

September 28-29, 2023

Kragujevac, Serbia

Sponsored by

2nd International Conference on Chemo and BioInformatics, Kragujevac, September 28-29, 2023, Serbia.

Editors:

Professor Dr. Zoran Marković

Professor Dr. Nenad Filipović

Technical Editors:

Jelena Živković

Marko Antonijević

Dr. Žiko Milanović

Dr. Vladimir Simić

Proofreading:

Marijana Dimović

Publisher:

Institute for Information Technologies, University of Kragujevac, Serbia, Jovana Cvijića bb, 2023

Press:

„Grafo Ink“, Kragujevac

Impression:

120 copies

CIP - Каталогизација у публикацији - Народна библиотека Србије, Београд

54:004(048)(0.034.2)
57+61]:004(082)(0.034.2)

INTERNATIONAL Conference on Chemo and BioInformatics (2 ; 2023 ; Kragujevac) Book of Proceedings [Elektronski izvor] / 2nd International Conference on Chemo and BioInformatics, ICCBIKG 2023, September 28-29, 2023 Kragujevac, Serbia ; [editors Zoran Marković, Nenad Filipović]. - Kragujevac : University, Institute for Information Technologies, 2023 (Kragujevac : Grafo Ink). - 1 USB fleš memorija ; 1 x 2 x 6 cm

Sistemski zahtevi: Nisu navedeni. - Nasl. sa naslovne strane dokumenta. - Tiraž 120. - Bibliografija uz svaki rad.

ISBN 978-86-82172-02-4

a) Хемија -- Информациона технологија -- Зборници b) Биомедицина -- Информациона технологија -- Зборници

COBISS.SR-ID 125908489

Organized by:

Institute for Information Technologies, University of Kragujevac, **Organizer**	Institute of Nuclear Science, University of Belgrade, *Suborganizer*
Faculty of Science, University of Kragujevac, *Suborganizer*	The Ministry of Science, Technological Development and Innovation of The Republic of Serbia, *Supporting organization*
Faculty of Technical Science, University of Kragujevac, *Suborganizer*	University of Kragujevac, *Supporting organization*
State University of Novi Pazar, *Suborganizer*	

Committees

International Organizing Committee:

Chairman:	Prof. Dr Zoran Marković (Serbia)
Vice-chairmans:	Prof. Miloš Kojić (USA)
	Prof. Dr. Mimoza Ristova (North Macedonia)

Members:

Dr Dejan Milenković (Serbia), Dr Marijana Petković (Serbia), Dr. Jasmina Grbović Novaković (Serbia), Prof. Dr. Aleksandar Ostojić (Serbia), Dr Jovana Sekulić (Serbia), Dr Edina Avdović (Serbia), Dr Dušica Simijonović (Serbia), Dr Tijana Geroski (Serbia), Doc. Dr Dušan Dimić (Serbia), Dr Ana Kesić (Serbia), Doc. Dr Svetlana Jeremić (Serbia), Dr Marija Ristić (Serbia), Dr Vladimir Simić (Serbia), Dr Žiko Milanović (Serbia), Marko Antonijević (Serbia).

International Scientific Committee:

Chairman:	Prof. Dr Nenad Filipović (Serbia)
Vice-chairmans:	Prof. Dr Snežana Pajović (Serbia)
	Prof. Dr Zlatan Car (Croatia)

Members:

Prof. Zoran Marković (Serbia), Prof. Ivan Gutman (Serbia), Prof. Miloš Kojić (USA), Prof. Miloš Đuran (Serbia), Prof. Nenad Kostić (USA), Prof. Ljiljana Kolar-Anić (Serbia), Prof. Svetlana Marković (Serbia), Prof. Snežana Zarić (Serbia), Prof. Marija Stanić (Serbia), Prof. Miroslav Živković (Serbia), Prof. Dr Nino Russo (Italy), Prof. Nenad Grujović (Serbia), Prof. Luciano Saso (Italy), Jasmina Dimitrić-Marković (Serbia), Prof. Dražen Vikić-Topić (Croatia), Prof. Zana Dolićanin (Serbia), Prof. Bakhtiyor Rasulev (USA), Prof. Enver Karahmet (Bosnia and Herzegovina), Prof. Themis Exarchos (Greece), Dr. Sc. Mario Vazdar (Czech Republic), Prof. Dr. Goran Kaluđerović (Germany), Prof. Dr. Jasmina Stevanović (Serbia), Prof. Dr Rudolf Bauer (Austria), Prof. Dr Slobodan Savić (Serbia), Prof. Dr. Petar Uskoković (Serbia), Prof. Dr. Danijela Milošević (Serbia), Prof Dr Janez Konc (Slovenia), Prof. Dr. Bartosz Trzaskowski (Poland), Prof. Dr Miljan Milošević (Serbia), Dr Edina Avdović (Serbia), Dr Katarina Marković (Serbia).

Local Executive Committee:

Chairman:	Prof. Dr Miljan Milošević (Serbia)
Vice-chairmans:	Dr Marina Kostić (Serbia)
	Dr Jasmina Obradović (Serbia)

Members:

Jelena Živković (Serbia), Bogdan Milićević (Serbia), Nevena Veselinović (Serbia), Momčilo Prodanović (Serbia), Emilija Milović (Serbia), Sandra Jovičić Milić (Serbia).

Numerical simulations of the oscillatory dynamics in the Bray-Liebhafsky reaction perturbed by L-tyrosine

Ana Ivanović-Šašić[1], Stevan Maćešić[2], Jelena Maksimović[2], Željko Čupić[1*], Ljiljana Kolar-Anić[2]

[1] University of Belgrade, Institute of Chemistry, Technology and Metallurgy, National Institute of the Republic of Serbia, Njegoševa 12, 11000 Belgrade
e-mail: ana.ivanovic.sasic@ihtm.bg.ac.rs, zcupic@ihtm.bg.ac.rs
[2] University of Belgrade, Faculty of physical chemistry, Studentski Trg 12-16, 11158 Belgrade
e-mail: jelena.maksimovic@ffh.bg.ac.rs, stevan.macesic@ffh.bg.ac.rs,

* *Corresponding author*

DOI: 10.46793/ICCBI23.609IS

Abstract: It is well known that almost all living or biological systems are naturally in the oscillatory dynamic states and can be considered as biochemical reaction systems. These oscillatory dynamic states can be caused by internal self-organized phenomena, but also by external periodic variations of temperature, light, food, or seasonal changes. The hypothalamic-pituitary-thyroid (HPT) axis is one such nonlinear system with feedback that is always in an oscillatory dynamic state and L-tyrosine is its main representative.

The biological importance of L-tyrosine interactions with iodine species was the motivation for modelling of the oscillatory dynamics in the Bray-Liebhafsky (BL) reaction perturbed by L-tyrosine. Also, direct experimental investigation of metabolic processes in the human body is extremely complex to be done, and therefore any alternative approach is of great importance. Therefore, the BL reaction has the potential to be used as a model of the biological system due to certain characteristics shared with the considered processes; it is characterized by its oscillatory dynamics and based on the chemistry of hydrogen peroxide and iodine compounds commonly present in the thyroid gland, where L-tyrosine is iodinated.

The impact of L-tyrosine on the dynamics of the Bray-Lienbhafsky oscillatory reaction was investigated numerically using the proposed model. The study was focused on the examination of the sensitivity of the BL reaction to L-tyrosine perturbation. The obtained results indicated possible pathways of influence.

Keywords: Numerical simulation, Bray-Liebhafsky oscilattory reaction, L-tyrosine

1. Introduction

The Bray-Liebhafsky (BL) oscillatory reaction [1], the first homogeneous oscillatory reaction presents hydrogen peroxide decomposition into the water and oxygen in the presence of iodate and hydrogen ions:

$$2H_2O_2 \rightarrow 2H_2O + O_2 \qquad \text{(D)}$$

This apparently simple reaction comprises a complex homogeneous catalytic oscillatory process involving periodic changes in concentrations of numerous iodine intermediates such as I_2 , I^-, HIO , I_2O and HIO_2.

2. Model

To explain L-tyrosine activity, numerical simulations were performed using the proposed model of the BL oscillatory reaction that exists of eight reactions, present in Table 1 [2].

Model of the Bray-Liebhafsky oscillatory reaction

$IO_3^- + I^- + 2H^+$	$\rightleftarrows$	$HIO + HIO_2$	(R1)
$HIO_2 + I^- + H^+$	$\longrightarrow$	$I_2O + H_2O$	(R2)
$I_2O + H_2O$	$\rightleftarrows$	$2HIO$	(R3)
$HIO + I^- + H^+$	$\rightleftarrows$	$I_2 + H_2O$	(R4)
$HIO + H_2O_2$	$\longrightarrow$	$I^- + H^+ + O_2 + H_2O$	(R5)
$I_2O + H_2O_2$	$\longrightarrow$	$HIO + HIO_2$	(R6)
$HIO_2 + H_2O_2$	$\longrightarrow$	$IO_3^- + H^+ + H_2O$	(R7)
$IO_3^- + H^+$	$\longrightarrow$	$HIO_2 + O_2 + H_2O$	(R8)

The dynamics of the considered system is described by five differential equations:

$$\frac{d[I^-]}{dt} = v_{-1} + v_{-4} + v_5 - v_1 - v_2 - v_4$$

$$\frac{d[HIO]}{dt} = v_1 + 2v_3 + v_{-4} + v_6 - v_{-1} - 2v_{-3} - v_4 - v_5$$

$$\frac{d[HIO_2]}{dt} = v_1 + v_6 + v_8 - v_{-1} - v_2 - v_7$$

$$\frac{d[I_2O]}{dt} = v_2 + v_{-3} - v_3 - v_6$$

$$\frac{d[I_2]}{dt} = v_4 - v_{-4}$$

3. Numerical simulation

Numerical simulations were performed in MATLAB, using the ODE15s solver routine based on the Gear algorithm for the integration of stiff differential equations. The response of the BL matrix to a low concentration of L-tyrosine single pulse perturbations was investigated. The system was perturbed with various concentrations (1.27×10^{-7} M − 1.27×10^{-5} M) of L-tyrosine in the pre-oscillatory period at the same instant of time (40 min).

4. Results and discussion

Previous experimental investigations show that the BL oscillatory reaction is the well-selected matrix for examination of the chemical activity of L-tyrosine. The mechanism of interaction between the L-tyrosine and BL reaction system constituents is therefore studied here by the numerical simulation of the BL reaction.

As the BL matrix is a very rich reaction system with many intermediate species and numerous reactions between them produce various parallel reaction pathways, and L-tyrosine is a reactive species, the selection of the reactions that describe their interactions was a difficult task. By the examinations of the main kinetic activities of L-tyrosine, we proposed a reaction with the aim of explaining a mechanism of L-tyrosine interaction with the BL matrix.

$$HIO + Tyr \rightarrow P \qquad \text{(RT)}$$

This reaction was chosen as the most probable pathway for interaction between L-tyrosine and BL reaction system. [3] Products of this reaction step are considered irrelevant for the nonlinear dynamics of BL reaction. Reaction (RT) is consistent with experimentally observed increase of iodide concentration after perturbation since HIO concentration is directly related to iodide concentration through very fast iodine hydrolysis. Therefore, a decrease in HIO concentration leads to an equilibrium shift toward a further increase in iodide concentration, a reaction (R4) from the model presented in Table 1.

Numerically simulated time evolution of the BL reaction was perturbed with various amounts of L-tyrosine. The rate constant of reaction (RT) is estimated to be $k_{RT} = 5.00 \times 10^{5}$ min^{-1}. Results obtained with the selected value of rate constant k_{R1} show that a very small amount of L-tyrosine produces an important response of the BL matrix. Sensitivity to perturbation by small amounts of L-tyrosine depends on the selected rate constant value.

Based on the results presented in Figure 1, it can be observed that the peak intensity and the length of the oscillogram depend on the value of L-tyrosine concentration. More precisely, with an increase in the concentration of L-tyrosine, both the peak intensity and the length of the oscillogram also increase as well as the period between perturbation and first oscillation. Therefore, it can be concluded that the system is sensitive to low concentrations of perturbators which is in accordance with previous experimental results.

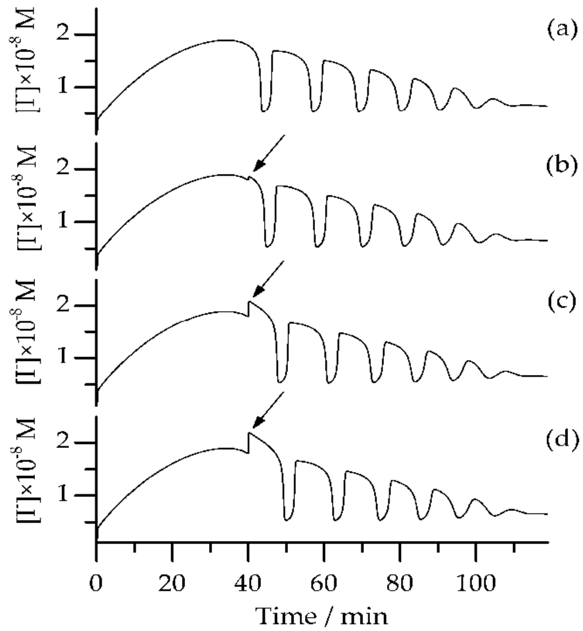

Figure 1. Numerically simulated time evolution of the BL reaction: (a) without perturbation and perturbated with different L-tyrosine concentration: (b) [Tyr] = 1.27×10^{-6} M, (c) [Tyr] = 6.33×10^{-6} M, (d) [Tyr] = 9.50×10^{-6} M. Arrow presents time of perturbation. The rate constant of reaction (RT) is determined to be $k_{RT} = 5.00 \times 10^5$ min^{-1}.

5. Conclusion

The impact of L-tyrosine on the dynamics of the Bray-Lienbhafsky oscillatory reaction was investigated numerically using the proposed model. The system was perturbated with various L-tyrosine concentrations. The obtained results show a very good potential of the BL reaction in the analysis of the L-tyrosine and indicated possible pathways of influence.

Acknowledgment

We are grateful to the financial support from Ministry of Science, Technological Development and Innovation of Republic of Serbia (Grant Numbers 172015 and 45001, and Contract numbers 451-03-47/2023-01/200026 and 451-03-47/2023-01/200146. This research was supported by Science Fund of Republic of Serbia #Grant Number. 7743504, NES.

References

[1] W.C. Bray, H.A. Liebhafsky, *Reactions involving hydrogen peroxide, iodine and iodate ion. I Introduction,* J America Chemical Society, 53 (1931)38-44.
[2] Lj. Kolar-Anić, Đ. Mišljenović, S. Anić, G. Nicolis, *The infuence of the reduction of iodate ion by hydrogen peroxide on the model of the Bray-Liebhafsky reaction*. Reaction Kinetics Catalysis Letters, 54 (1995) 35–41.
[3] H.B. Dunford, I.N. Ralston, *On the Mechanism of iodination of tyrosine*, Biochem. Biophys. Res. Commun. 116 (1983) 639-643.